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Yoshii et al.

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[54] **REFRIGERANT EVAPORATOR**

[75] Inventors: **Keiichi Yoshii; Masahiro Shimoya**, both of Kariya, Japan

[73] Assignee: **Nippondenso Co., Ltd.**, Kariya, Japan

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**^{6} **F28D 1/02**; F25B 41/06

[52] **U.S. Cl.** **62/513**; 62/527; 165/153; 165/DIG. 465

[58] **Field of Search** .... 165/153, DIG. 465, 165/467; 62/513, 515, 527

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Primary Examiner—William E. Wayner

Attorney, Agent, or Firm—Cushman, Darby & Cushman IP Group of Pillsbury Madison & Sutro LLP

[57] **ABSTRACT**

A refrigerant evaporator **5** constructed by a refrigerant-refrigerant heat exchanger section **32** having an inflow passageway **38** and an outflow passageway **39**, and a refrigerant-air heat exchanger section **34** having a bottom tank **48**, a top tank **49** and evaporating passageways **100** connecting the tanks **48** and **49** with each other. An orifice **33** is arranged between the inflow passageway **38** of the refrigerant-air heat exchanger section **34** and the inlet tank **48** of the refrigerant-air heat exchanger section **34**. The refrigerant in the bottom tank **48** is introduced into all of the evaporating passageways **100**, so as to obtain a single, upward direction of flow of the refrigerant in the evaporating passageways **100**.

3 Claims, 8 Drawing Sheets

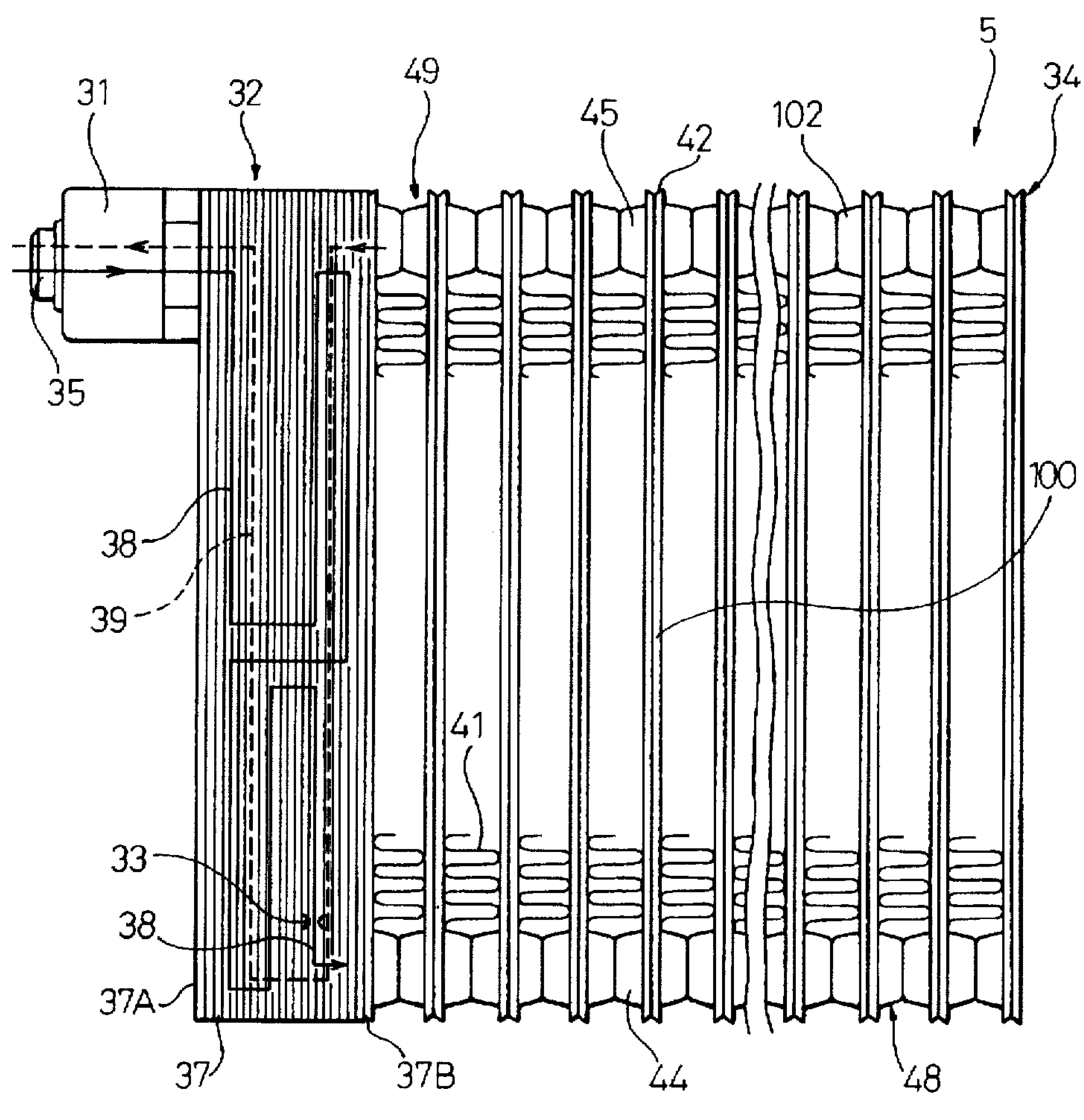

Fig.1

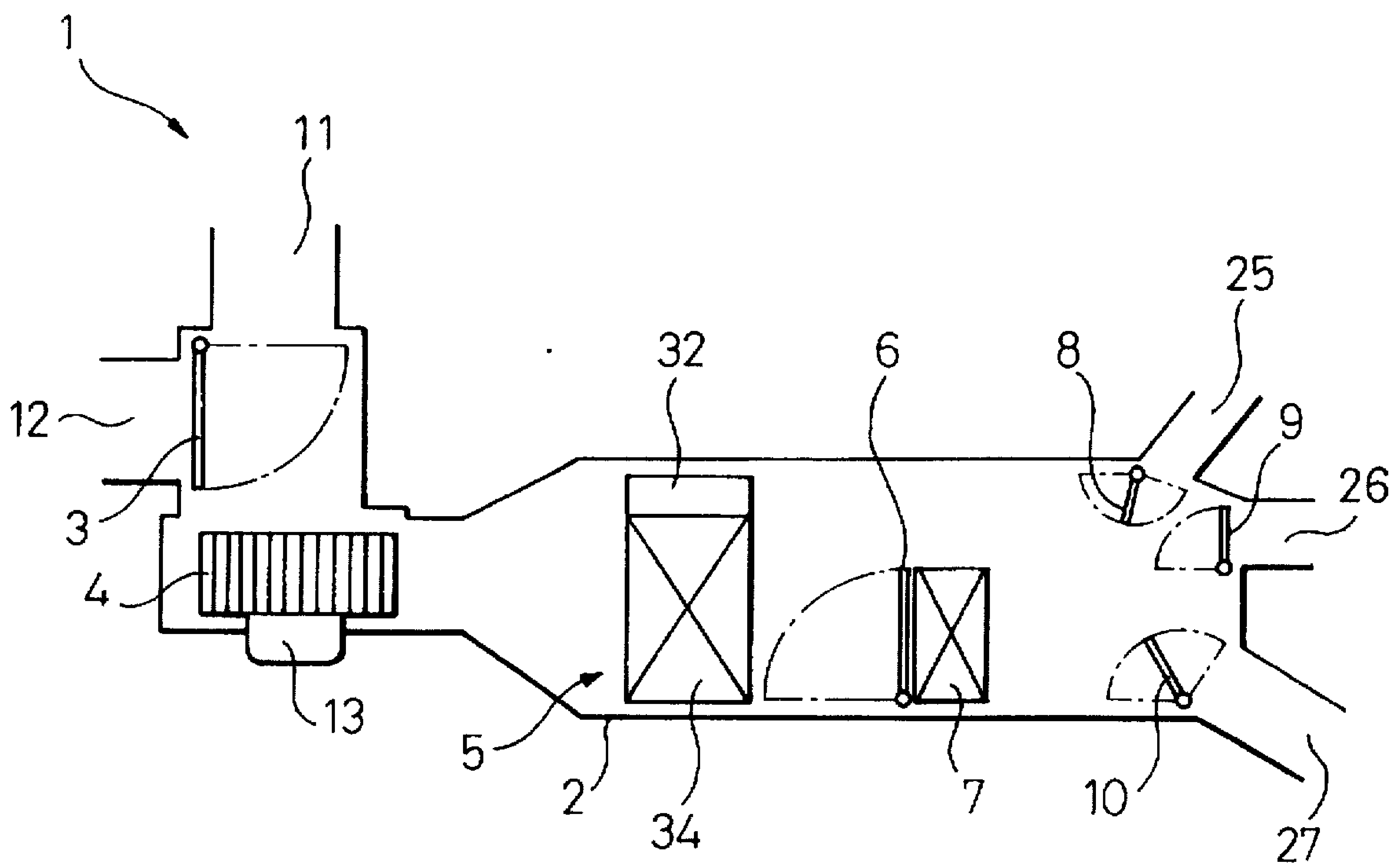

Fig.2

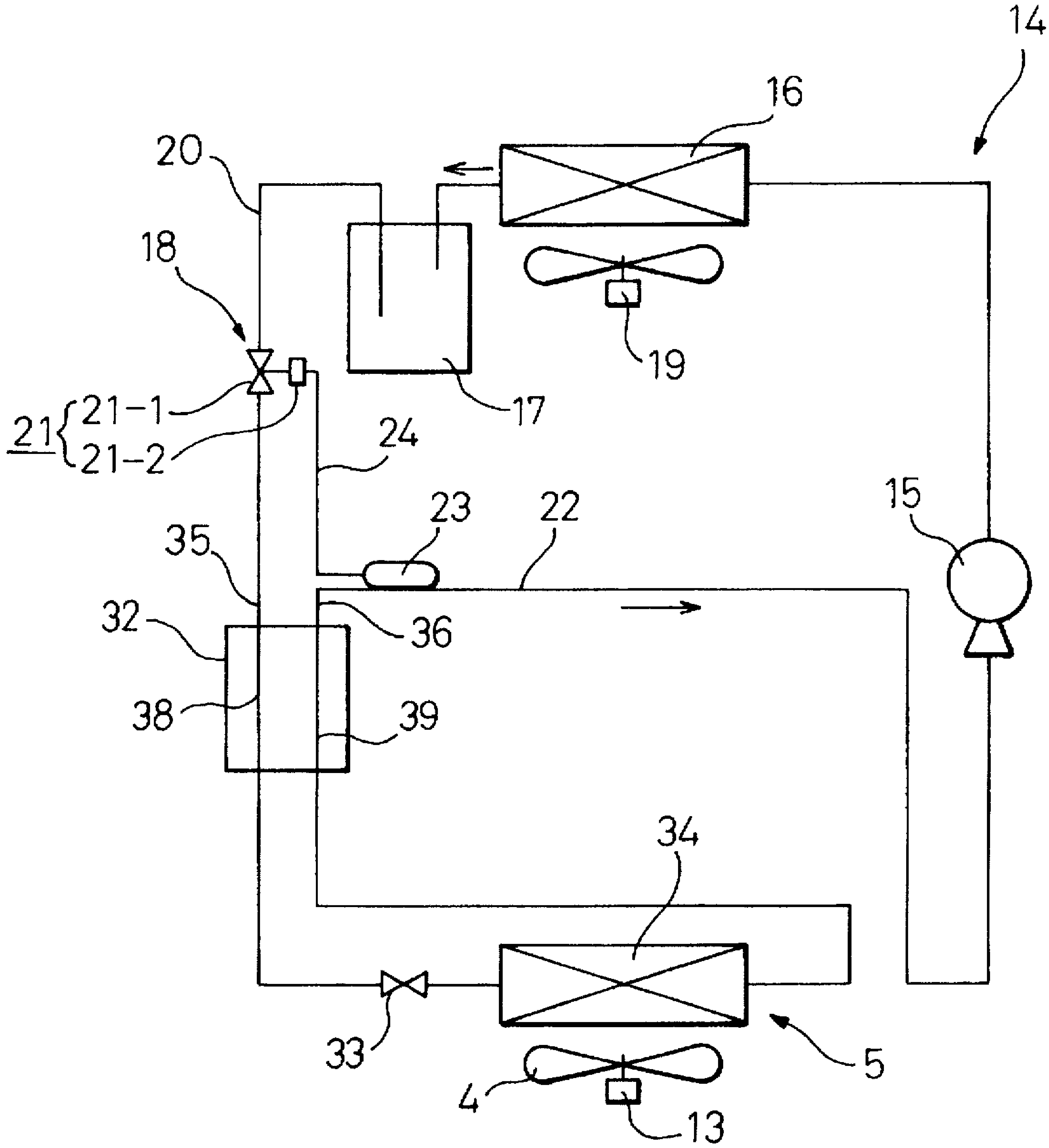

Fig.3

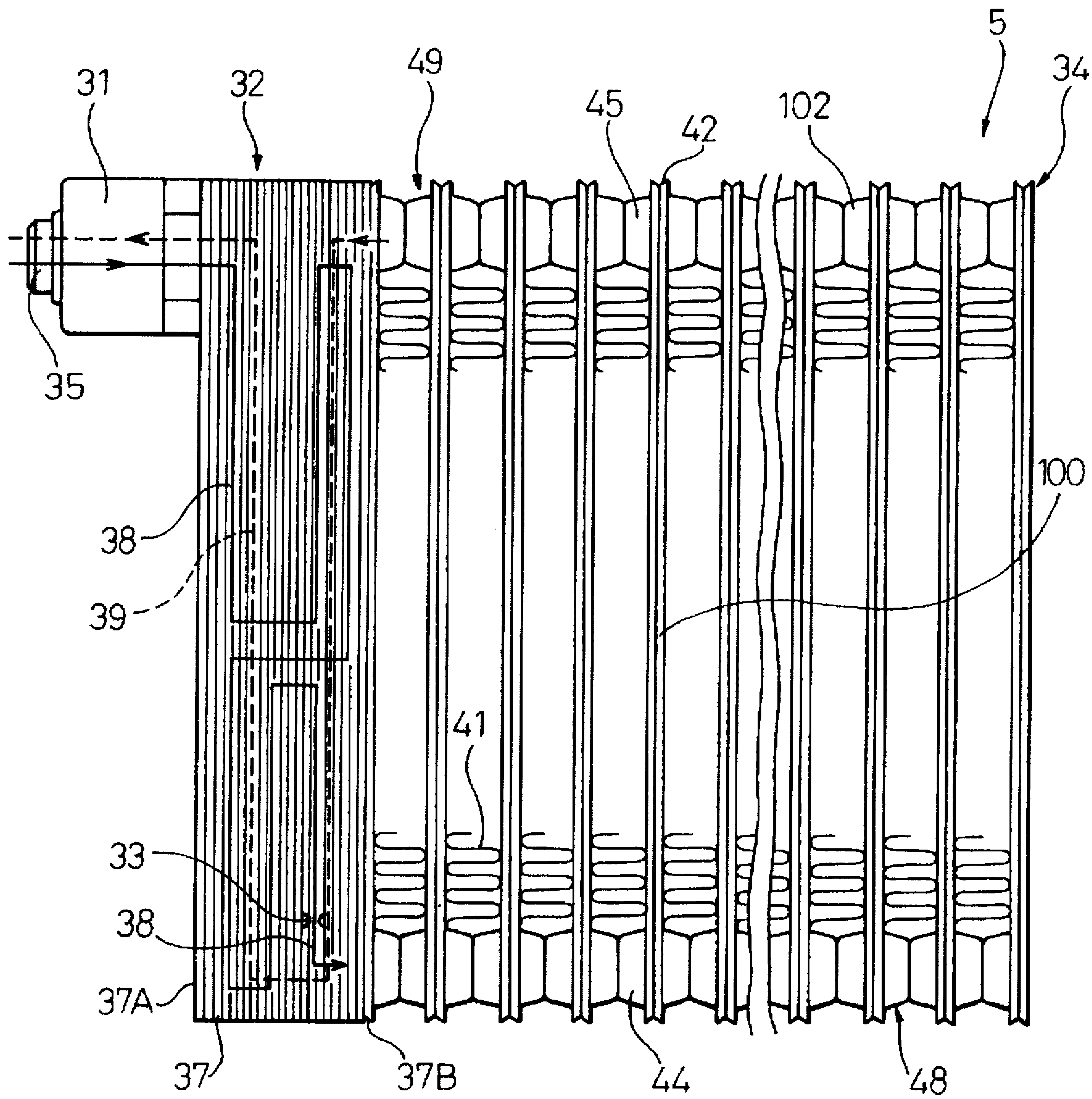

Fig. 4

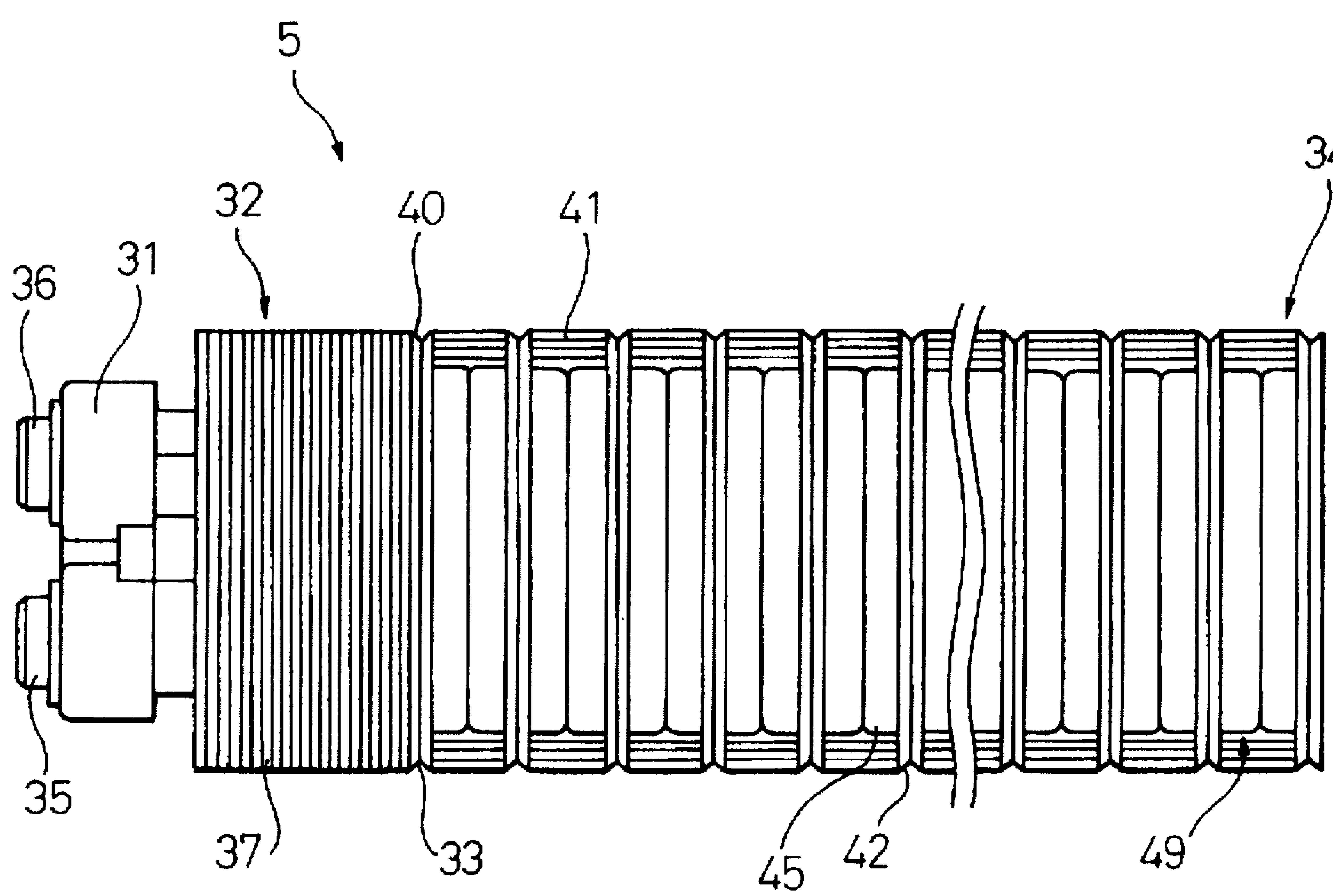

Fig.5

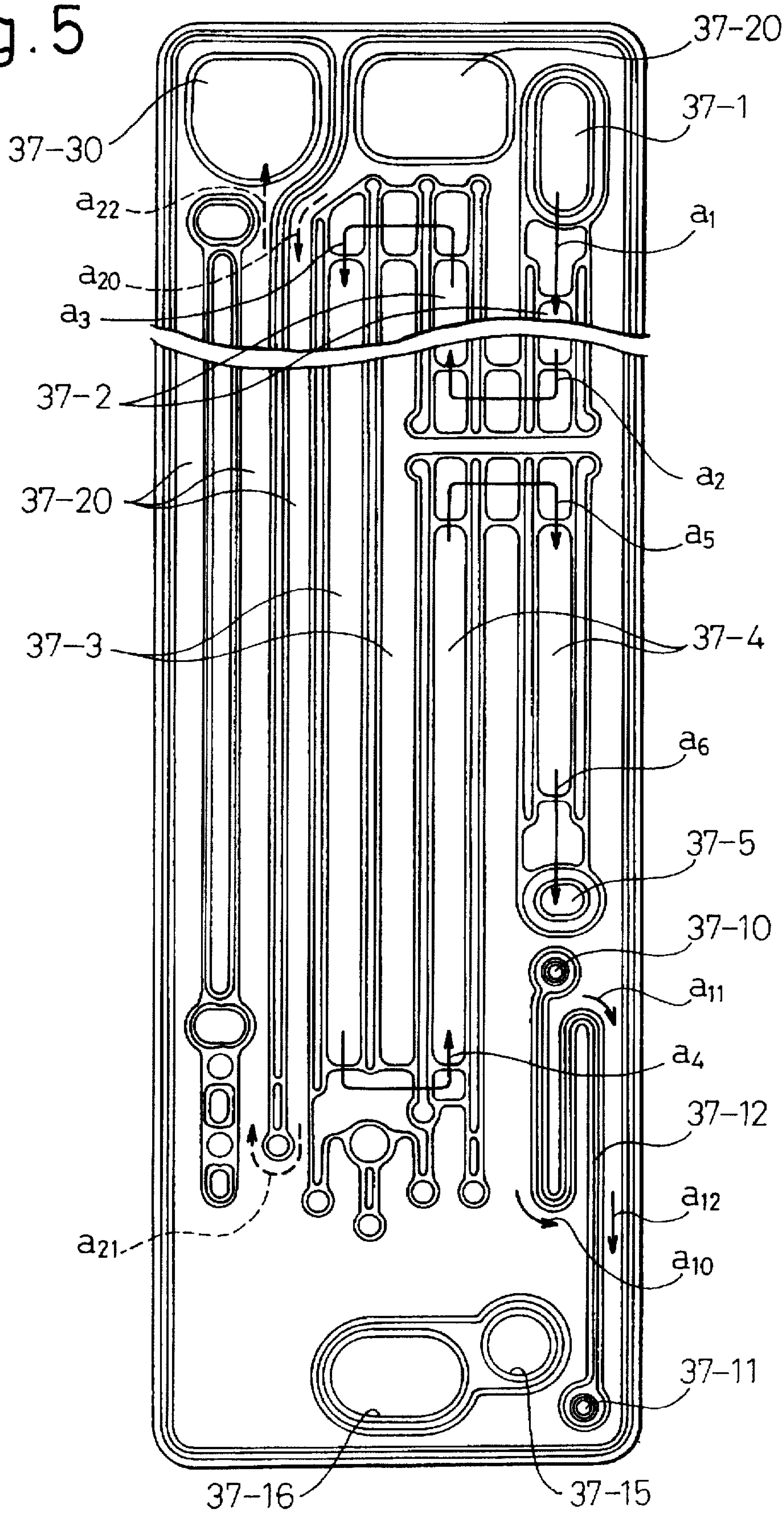
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Fig.6

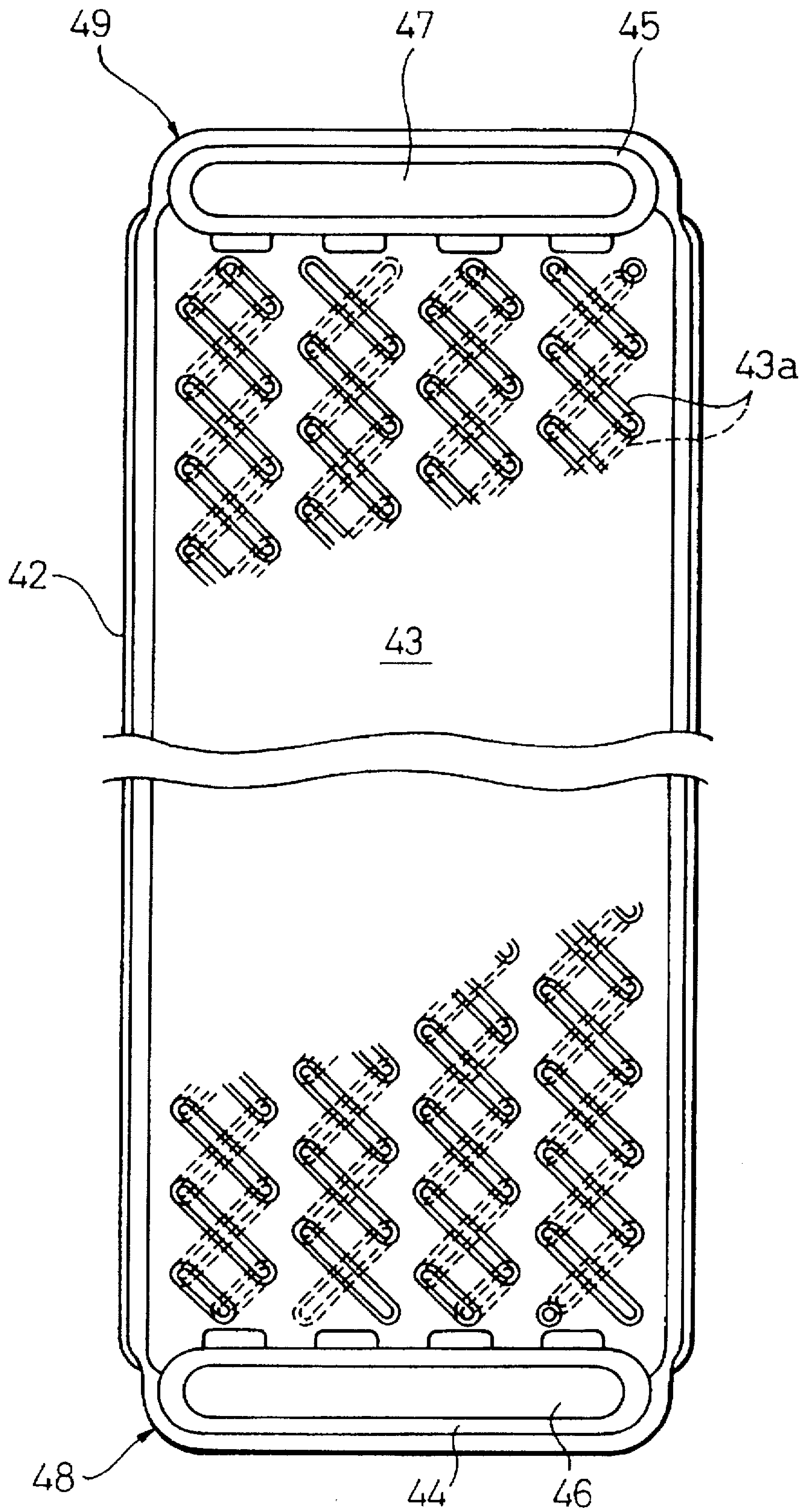


Fig.7

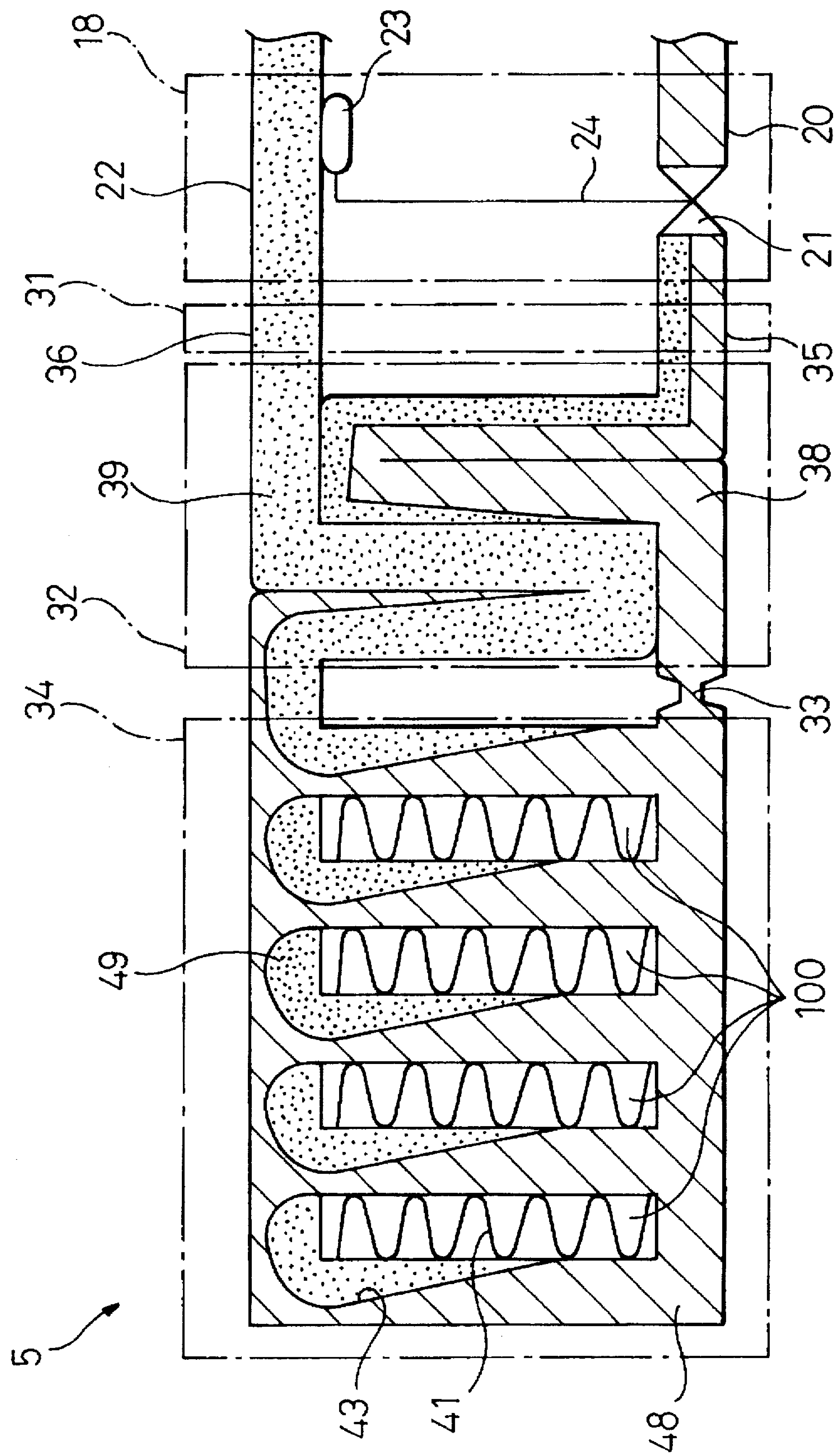
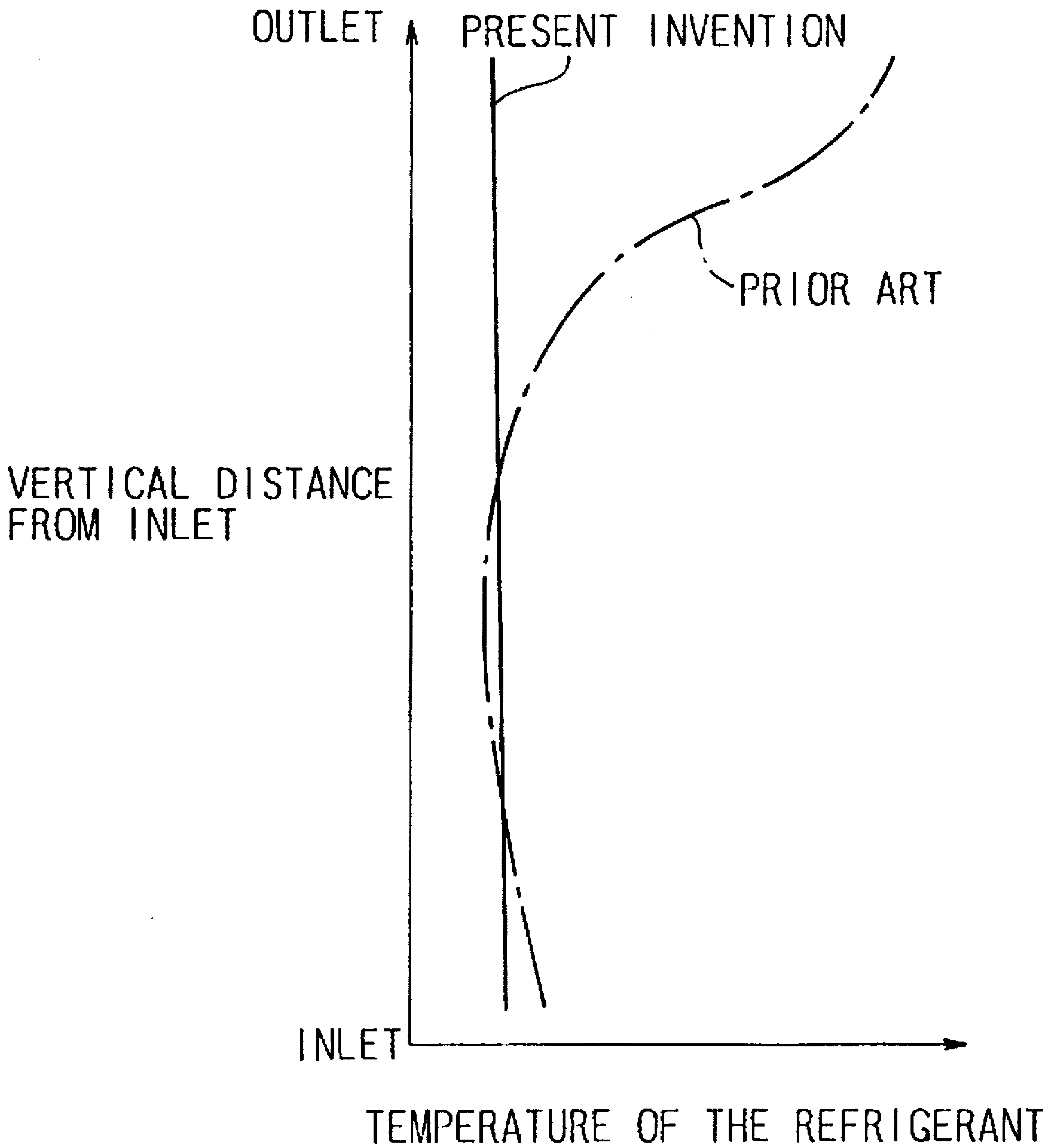


Fig.8


OUTLET
PRESENT INVENTION
PRIOR ART
VERTICAL DISTANCE FROM INLET
INLET
TEMPERATURE OF THE REFRIGERANT

REFRIGERANT EVAPORATOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a refrigerant evaporator, wherein the flow of the refrigerant is divided into a plurality of refrigerant evaporating passageways. The present invention relates, more particularly, to an improvement of a type of refrigerant evaporator wherein a vaporized refrigerant is prevented from forming any superheated area at outlets of the refrigerant evaporating passageways, thereby improving the uniformity of the temperature distribution in a discharged air flow.

2. Description of Related Arts

In an air conditioning apparatus, there has been a long felt need that a temperature distribution as uniform as possible is obtained in an air flow discharged from an evaporator. In order to attain this, an evaporator is proposed, wherein an inlet tank is connected to a plurality of evaporating passageways, so that a flow of the refrigerant from the inlet tank downstream from an expansion valve is divided into a plurality of evaporating passageways, so that the refrigerant is uniformed distributed between the evaporating passageways. In this case, the refrigerant introduced, from the expansion valve, to the inlet tank is under a gaseous-liquid combined state, which makes it difficult for the refrigerant from the inlet tank to be uniformly distributed between the refrigerant passageways.

In view of this difficulty, a solution has heretofore provided wherein a pair of tanks are provided, between which a plurality of U-shaped passageways are, at their opposite ends, connected. Separators are arranged in the respective tanks so that the U-shaped passageways are divided into three groups and the number of the refrigerant passageways partitioned by the separators is reduced, so that a direction of the flow of the refrigerant is turned twice or triple, which allows the refrigerant to be evenly distributed to the U-shape passageway in one group of the refrigerant passageways, thereby obtaining a uniform distribution of the temperature of the discharged from the duct into the cabin.

However, in the prior art, the length of the refrigerating passageway from the inlet to the outlet is prolonged, on one hand, and the effective area of the refrigerating passageway is reduced, on the other hand, thereby increasing a pressure loss across the U-shaped passageway. Such an increase in the pressure loss causes the flow resistance to be increased, which causes an average value of the evaporating pressure of the refrigerant to be inevitably increased in the evaporating system, when a flow amount is maintained equal to that obtained by a refrigerant passageway of smaller pressure loss. Such an increase in the flow resistance causes the temperature of the refrigerant to be increased, which results in a reduction in a difference between the temperature of the air and the temperature of the refrigerant. As a result, a heat exchanging capacity is reduced, i.e., a cooling capacity of the air is reduced.

Furthermore, in order to prevent a liquid state compression occurring in a compressor, which, together with the refrigerant, constructs a refrigerating system, the evaporation of the refrigerant should complete its evaporation before the refrigerant is discharged from the outlet of the evaporator. In order to do this, it is usual that a superheating area is provided at the outlet of the refrigerant evaporator, where the refrigerant flowing in the evaporator is under a super heated vapor condition. However, an existence of such a superheated area at the outlet of the evaporating passageway causes a temperature variation to be increased between the inlet of the evaporating passageway and the outlet of the same, resulting in a variation in a heat exchanging efficiency of the refrigerant with respect to the air flow contacting the evaporator. Namely, the existence of the superheated area causes a difference to be generated between the temperature of the discharged air passed through a portion around the inlet of the refrigerant passageway and the temperature of the discharged air passed through the portion around outlet of the refrigerant passageway, so that the temperature distribution of the discharged air is likely to be uneven.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a refrigerant evaporator capable of improving the distribution of the refrigerant by obtaining a pure liquid state of the refrigerant at the inlets of a plurality of the refrigerating passageways.

Another object of the present invention is to provide a refrigerant evaporator capable of improving a distribution of the air temperature by eliminating the superheated area at the outlet of the plurality of the refrigerating passageways.

Still another object of the present invention is to provide a refrigerant evaporator capable of preventing an occurrence of the liquid state compression by obtaining a superheated condition of the refrigerant which is discharged from the evaporator.

Further object of the present invention is to provide a refrigerant evaporator capable of preventing a reduction in a cooling ability by reducing the pressure at the plurality of the refrigerating passageways.

Further another object of the present invention is to provide a refrigerant evaporator capable of increasing a heat transfer performance between the refrigerant and the air by allowing the air flow to be directed from the bottom to the top in the plurality of the refrigerating passageways.

According to the present invention, an evaporator is provided, comprising:

- a first heat exchanger for obtaining a heat exchange between a flow of a refrigerant and a flow of an air, and;
- a second heat exchanger having an inflow passageway and an outflow passageway, which are arranged to obtain a heat exchange between a flow of the refrigerant in the inflow passageway and a flow of the refrigerant in the outflow passageway;
- said first heat exchanger comprising an inlet tank connected to the inflow passageway for receiving the flow of the refrigerant therefrom, an outlet tank arranged above the inlet tank and connected to the outflow passageway for discharging the flow of the refrigerant therefrom and air-refrigerant heat exchanging means for defining a plurality of heat exchange passageways horizontally spaced in parallel, all of the heat exchanging passageways being, at their bottom ends, connected to the inlet tank and, at their top ends, to the outlet tank, thereby obtaining one way flow of the refrigerant in the heat exchange passageways from said bottom ends to said top ends.

BRIEF EXPLANATION OF ATTACHED DRAWINGS

FIG. 1 is a schematic view of an air conditioning apparatus for an automobile.

FIG. 2 is a schematic view of a refrigerating system in the air conditioning apparatus in FIG. 1.

FIG. 3 is a front elevational view of an evaporator in the refrigerating system in FIG. 2.

FIG. 4 is a top plan view of an evaporator in the refrigerating system in FIG. 2.

FIG. 5 is a front view of a heat exchanging plate of the refrigerant-refrigerant heat exchanging section of the evaporator.

FIG. 6 is a front view of a heat exchanging plate of the air-refrigerant heat exchanging section of the evaporator.

FIG. 7 is a schematic view of the evaporator in FIG. 3 for an illustration of an evaporating operation.

FIG. 8 is relationships between a temperature of the refrigerant and a vertical position of a refrigerating passageway from its inlet.

DESCRIPTION OF A PREFERRED EMBODIMENT

Now, an embodiment of the present invention will be explained with reference to attached drawings, which shows an application of the present invention to an air conditioning apparatus for an automobile. In FIG. 1, a reference numeral 1 denotes an air conditioning apparatus, which includes a duct 2 having an upstream end for taking an outside air into the duct and a downstream end for discharging the air flow into a cabin of the automobile. At an upstream end of the duct 1, a switching damper 3 is located, which is connected to an actuator such as a servo-motor, so that the switching damper 4 is moved between a first position as shown by a solid line, where an air flow is introduced into the duct 2 from an outside air inlet 11, so that an atmospheric air is introduced into the duct 1, and a second position as shown by a phantom line, where an air flow is introduced into the duct 2 from an inside air inlet 11, so that an air from the cabin is introduced into the duct 1.

Downstream from the switching damper 3, a blower 4 is arranged in the duct 2. The blower 4 is connected to a blower motor 13, which generates the rotating movement applied to the blower 4.

A refrigerant evaporator 5 in a refrigerating system for executing a refrigerating cycle is arranged in the duct 2 at a position downstream from the blower 4. The refrigerant evaporator is constructed as a well known type including a plurality of stacked pipes. As shown in FIG. 2, the refrigerating system, which is generally shown by a reference numeral 14, includes, in addition to the evaporator 5, a compressor 15 for generating a flow of compressed refrigerant, a condenser 16 receiving the compressed refrigerant from the compressor 15, a receiver 16 at the outlet of the condenser 16 for separating a liquid phase of the refrigerant, and a temperature operated expansion valve 18 for reducing the pressure of the refrigerant introduced into the evaporator 34. The compressor 15 includes a rotating shaft, which is in a kinematic connection with a crankshaft of an internal combustion engine (not shown) by way of an electromagnetic clutch (not shown). As a result, an engagement of the electromagnetic clutch causes the rotating movement of the crankshaft to be transmitted to the rotating shaft of the compressor 15, thereby generating the flow of the compressed refrigerant.

In a well known manner, the compressed refrigerant at high pressure and temperature is condensed at the condenser 16, while a flow of an outside air generated by an outside cooling fan 19 is contacted with the condenser 16. As a result, a heat exchange is occurred between the flow of the outside air and the flow of the refrigerant, thereby cooling and liquidizing the refrigerant. The liquid phase refrigerant from the receiver is, at the expansion valve 18, subjected to an expansion so that the pressure of the refrigerant is reduced. The expansion valve 18 is provided with a temperature sensitive control mechanism for controlling the pressure reduction, i.e., an amount of a recirculated refrigerant for obtaining a constant degree of a superheat of the refrigerant an the outlet of the evaporator 5, so that evaporation of the refrigerant is completed before the refrigerant is issued from the outlet of the evaporator 5. Namely, the temperature sensitive control mechanism is constructed by a valve unit located in a refrigerant recirculating pipe 20 between the receiver 17 and the evaporator 5 and a temperature sensitive tube 23 which is arranged adjacent to a location of a refrigerant recirculating pipe 22 between the evaporator 5 and the compressor 15. In a well known manner, the valve unit 21 is constructed by a needle valve 21-1 and a diaphragm actuator 21-2, which is in communication with the temperature sensitive tube 23 via a capillary conduit 24.

In FIG. 1, an air mix damper 6 and a heater core 7 are arranged in the duct 2 at a location downstream from the evaporator 34. The heater core 6 has an inlet (not shown) for receiving a hot water from a cooling system (not shown) of the internal combustion engine and an outlet for returning the hot water to the engine cooling system. At the heater core, a heat exchange occurs between the engine hot water and an air flow in the duct 2. The air mix damper 6 is connected to a servomotor (not shown) and is moved between a closed position as shown by a solid line where the heater core 7 is closed by the air mix damper 6 and the air flow by-passes the heater core and an opened position as shown by a dotted line where the heater core 7 is opened so that the air flow can pass through the heater core. Furthermore, the air mix damper 6 can take a desired intermediate position between the closed position and opened position, so that a ratio between the amount of the air passed through the heater core 7 and the amount of the air by-passing the heater core 7, which ratio corresponds to the temperature of the discharged air, is desirably controlled.

At the downstream end, the duct 2 is formed with a defroster outlet 25 opened to a bottom of a windshield (not shown), an upper outlet 26 opened to an upper part of the cabin, and a lower outlet 27 opened to a lower part of the cabin. A defroster damper 8, an upper outlet damper 9 and a lower outlet damper 10 are provided for controlling the defroster outlet 25, the upper outlet 26 and the lower outlet 27, respectively. Servomotors are connected to the dampers 8, 9 and 10, respectively. Namely, the defroster damper 8, the upper outlet damper 9 and the lower outlet damper 10 are selectively operated such that a mode selection is executed between an upper outlet mode where a cold air flow is mainly discharged from the upper outlet 26 toward upper part of a driver or a passenger, a lower outlet mode where a hot air flow is mainly discharged from the lower outlet 27, a bi-level mode where a cold air flow is discharged from the upper outlet 26 and a hot air flow is discharged from the lower outlet 27, a lower-defroster outlet mode where a hot air flow is discharged from the defroster and upper outlets 25 and 26, and a defroster outlet where a hot air flow is discharged from the defroster outlet 25.

As shown in FIGS. 3 and 4, the evaporator 5 is basically constructed by a joint block 31, a refrigerant-refrigerant heat exchanger 32 and a refrigerant-air heat exchanger 34. The joint block 31 has an inlet conduit 35 for connecting the evaporator 5 to the pipe 20 to the valve body 21 of the temperature operated expansion valve 18 for allowing the liquid state refrigerant to be introduced into the evaporator 5 and has an outlet conduit 36 for connecting the evaporator 5 to the pipe 22 for allowing the gaseous state refrigerant to be returned to the compressor 15.

The refrigerant-refrigerant heat exchanger **32** is for obtaining a heat exchange between an inflow of the refrigerant to the refrigerant-air heat exchanger **34** and an outflow of the refrigerant from the refrigerant-air heat exchanger **34**, so that the inflow of the refrigerant is liquidized and the outflow of the refrigerant is vaporized or superheated. The refrigerant-refrigerant heat exchanger **32** is constructed by a stack of heat exchanging plates **37** sandwiched between a front end plate **37A** and a rear end plate **37B**. As shown in FIG. **5**, a heat exchanging plate **37** is formed as an elongated plate having an inlet opening **37-1** in communication with the inlet conduit **35**, grooves **37-2** on one side of the plate **37** extending from a top end to a middle location, grooves **37-3** extending along the entire height, grooves **37-4** extending from a bottom end to a middle location, and an outlet opening **37-5** so as to construct an inflow passageway **38** (FIG. 3). As a result, an inflow of the refrigerant as shown by arrows a_1, a_2, a_3, a_4, as and a_6 is obtained. The flow from the opening **37-5** is moved toward the rear end plate **37B** in FIG. **3**, whereat the flow direction is reversed. The heat exchanging plate **37** has an opening **37-10** for receiving the reversed flow, a serpentine groove **37-12** of a small width, and an opening **37-11** for receiving the refrigerant from the groove **37-12**. As a result, a serpentine flow of the refrigerant as shown by an arrow a_{10}, a_{11} and a_{12} is obtained. The grooves **37-12** of the exchanging plates **37** function as a capillary **33** (FIG. 7). The flow from the capillary is moved toward the front end plate **37A** in FIG. **4**, whereat the flow direction is reversed. The heat exchanging plate **37** has an openings **37-15** and **37-16** for receiving the reversed flow from the capillary. The opening **37-15** is, via an opening (not shown) in the rear end plate **37B**, introduced into the refrigerant-air heat exchanger **34**, the construction of which will be described later in detail. The refrigerant flows upwardly in the refrigerant-air heat exchanger **34** and is returned to the refrigerant-refrigerant heat exchanger **32** and a heat exchanging plate **37** has an opening **37-20** for receiving the returned flow. On the side opposite the side on which the groves **37-2** and **37-3** are formed, a heat exchanging plate **37** further has vertical grooves **37-20** along entire height, so as to construct an outflow passageway **39** (FIG. 3), so that a flow of the outflow of the refrigerant as shown by arrows a_{20}, a_{21} and a_{22} is obtained, so that a heat exchange is occurred between the inflow of the refrigerant on the first side of the plate **37** as shown by the arrows a_1, a_2, a_3, a_4, a_5 and a_6 and the outflow of the refrigerant as shown by the arrows a_{20}, a_{21} and a_{22}. Finally the heat exchanging plate **37** has an opening **37-30** for receiving the outflow of the refrigerant, which is returned, via the conduit **36**, to the pipe **22** and to the compressor **15**.

As shown in FIG. **3**, the refrigerant-air heat exchanger **34** is constructed as a stack of heat exchange plates **42** and corrugated fins **41** arranged between adjacent heat exchange plates **42**. As shown in FIG. **6**, on each of the heat exchange plates **42** is formed, on one side, a recessed portion **43**, and is formed, on the other side, a bottom and top cup shaped portions **44** and **45**. The cup shaped portions **44** and **45** extend along the entire width of the heat exchanging pipe **42** and form elongated openings **46** and **47**. The heat exchange plates **42**, which are adjacent with each other, are arranged so that the recessed portions **43** face each other, so that vertically extending refrigerant passageways **100** are created between the plates **42**. The bottom cup shaped portions **44** in the stacked condition of the plates **42** are in a series arrangement so that a bottom (inlet) tank **48**, which extends horizontally, is created. The top cup shaped portions **45** in the stacked condition of the plates **42** are in a series arrangement so that a top (outlet) tank **49**, which extends horizontally, is created. The bottom tank **44** is in communication with the outlet openings **37-16** (FIG. 5), so that the refrigerant in the inflow passageway after the capillary **37-12** in the refrigerant-refrigerant heat exchanger **32** is introduced into the bottom tank **48**. The refrigerant from the bottom tank **48** moves upwardly in the vertical passageways **100** and is introduced into the upper tank **49**. The upper tank **48** is in communication with the openings **37-20** (FIG. 5), so that the refrigerant from the tank **48** is introduced into the outflow passageway in the refrigerant-refrigerant heat exchanger **32**.

The refrigerant-air heat exchanger **34** functions to obtain a heat exchange between the refrigerant after it is passed through the capillary **37-12** and the air flow contacting with the heat exchanging plates **42** and the fins **41**, so that the refrigerant is vaporized, while the air flow is cooled. These fins **41** and the heat exchanging plates **42** in the stacked condition are connected with each other by a brazing. The heat exchanging plates are made as a pressed work from a thin aluminum based alloy material. As shown in FIG. **6**, the heat exchanging plate **42** is, at the recessed portion **43**, formed with a plurality of inclined ribs **43***a* along the entire area of the portion **43**, which is crossed with similar ribs as shown by dotted lines formed on the recessed portion **43** on the faced heat exchanging plate **42**. The provision of ribs **43** allow the flow of the refrigerant at the vertical passageways **100** to be zigzagged, thereby increasing a heat exchanging capacity.

According to the present invention, the arrangement of the plurality of the horizontally spaced vertically extending heat exchanging passageways **100** of the refrigerant-air heat exchanger **34** is such that the flow of the refrigerant is only directed vertically from the bottom tank **49** to the top tank **49**. In other words, the flow of the refrigerant is introduced into all of the passageways **100**, while the flow is unidirectional from the bottom tank **49** to the top tank.

Now, an operation of the air conditioning apparatus according to the present invention will be explained. An energization of the clutch (not shown) causes the rotating movement of the crankshaft of the internal combustion engine to be transmitted to the compressor **15**. As a result, compressed refrigerant from the compressor **15**, at a high temperature and pressure, is introduced into the condenser **16**. At the condenser **16**, the refrigerant is contacted with the flow of the outside air by the fan **19**, so that the refrigerant is cooled, thereby liquidizing the refrigerant. A phase separation occurs at the receiver **17**, so that a liquidized refrigerant is introduced into the temperature controlled expansion valve **18**, whereat the pressure of the refrigerant is reduced, thereby providing a gas-liquid combined state of the refrigerant. Then, the gas-liquid combined state refrigerant is introduced into the inflow passageway **38** of the refrigerant-refrigerant heat exchanger. The refrigerant flowing in the passageway **38** is subjected to a heat exchange with the refrigerant flowing in the passageway **39**. FIG. **7** schematically illustrates the heat exchange operation between the passageways **38** and **39**. Namely, in FIG. **7**, the liquid the liquid phase of the refrigerant is represented by shaded lines, while the gaseous phase of the refrigerant is represented by an assembly of dots. The liquid state refrigerant is after being passed through the expansion valve, changed to the gas-liquid combined state. By the heat exchange between the passageways **38** and **39**, the refrigerant in the passageway **38** is cooled and is changed into the liquid state.

The liquid state refrigerant is subjected to the pressure reduction when passed through the capillary **33**, and is introduced into the bottom tank **48** of the refrigerant-gas heat exchanger **34** in the liquid state. The refrigerant in the bottom tank **48** is evenly distributed to all of the refrigerant passageways **43** connected to the bottom tank **48**, and is moved upwardly toward the top tank **49** without turning the direction of the flow. When the refrigerant passes through the refrigerant passageways **43**, a heat exchange occurs with respect to the air flow in the duct **2** of the air conditioning apparatus, so that the refrigerant is vaporized. As a result of the heat exchange with the evaporated refrigerant at the passageways **43**, the air contacting therewith in the duct **2** is cooled, and is discharged into the cabin from a selected outlet, such as the top outlet **26**. In this embodiment of the present invention, the refrigerant should be under a superheated condition to a desired degree of the superheat at the outflow passageway **39** of the refrigerant-refrigerant heat exchanger **32**. In other words, the refrigerant at the refrigerant passageways **43** of the refrigerant-air heat exchanger **34** is in a partially liquidized state.

The refrigerant flows issued from the respective refrigerant passageways **43** are combined at the outlet tank **49** and are discharged into the outflow passageway **39** of the refrigerant-gas heat exchanger. Due to the heat exchange with the refrigerant in the inflow passageway **38**, the refrigerant in the outflow passageway **39** is heated, so that a value of the degree of the superheating of the refrigerant in the outflow passageway **39** is larger than 1.0, thereby obtaining a superheated refrigerant before it is supplied to the compressor **15**.

As explained above, in the air conditioning apparatus **1** for a vehicle according to the present invention, the fixed orifice (capillary) **33** constructed by the grooves **37-12** is provided, so that the refrigerant from the inflow passageways **38** is, under a gas-liquid combined state, introduced into the inlet (bottom) tank **48** and the inflow passageways **38**, of the refrigerant-air heat exchanger. The gas-liquid combined state in the inlet tank **48** allows the refrigerant to be evenly distributed to all of the refrigerant passageways **100**. In other words, the construction according to the present invention does not cause the distribution of the refrigerant to be uneven between the refrigerant passageways **100**. Furthermore, according to the present invention, the refrigerant at the outlet of the refrigerant passageways **100** is prevented from becoming superheated. Rather, the superheated condition of the refrigerant (value of the degree of the overheating larger than 1.0) is obtained at an outlet of the outflow passageway **39** of the refrigerant-refrigerant heat exchanger **32**. As a result, an effective heat exchange of the refrigerant with respect to the air is obtained. In FIG. **8**, a solid line shows a relationship between the temperature of the refrigerant and a distance of a refrigerant evaporating passageway **100** from its inlet in a direction of the flow of the refrigerant in the embodiment of the present invention. As will be easily seen, a substantially uniformed temperature is obtained along the entire length from the inlet to the outlet of the refrigerant evaporating passageway **100**. In particular, an increased in the temperature of the refrigerant at the outlet of the refrigerant evaporating passageway **100** is prevented, thereby obtaining a uniform heat exchanging capacity, i.e., a cooling performance of the stacked type of the evaporator **5** along its entire area.

In view of the above, a uniform distribution of the temperature of the discharged air after contacted with the plurality of refrigerant evaporating passageways **100** is obtained not only along the entire width of the refrigerant-air heat exchanger **34**, i.e. in the direction parallel to the arrangement of the plurality of refrigerant evaporating passageway **100** but also along the entire height of the refrigerant-air heat exchanger **34**, i.e., in the vertical direction.

Furthermore, a flow of the refrigerant in each of the refrigerant evaporating passageways **100** is obtained from its bottom portion to its top portion against the force of the gravity. As a result, a well mixed state is obtained between a liquid phase of the refrigerant likely to be located mainly at a core portion of the refrigerant evaporating passageway **100** and a gaseous phase of the refrigerant likely to be located at a peripheral portion of the refrigerant evaporating passageway **100**. As a result, a quick movement of the liquid phase of the refrigerant toward the inner side of the refrigerant pipe at a relatively high temperature is obtained, which allows the refrigerant to be effectively subjected to a heat exchange with respect to the air flow contacting the outer wall of the pipe. In other words, an improved heat exchange capacity is obtained according to the present invention over a prior art construction where the refrigerant flows in the heat exchange pipe from its top portion to its bottom portion.

According to the present invention, in the refrigerant-refrigerant heat exchanger **32**, the direction of the flow of the refrigerant in the inflow passageway **38** and the direction of the flow of the refrigerant in the outflow passageway **39** are opposite to each other, which allows the heat exchanging efficiency to be improved between the inflow refrigerant and the outflow refrigerant in the refrigerant-refrigerant heat exchanger **32**. As a result, a super-heated condition of a value of the degree of the superheating of the refrigerant larger than 1.0 is obtained at the outlet of the stacked type heat exchanger **5**. As a result, the refrigerant is prevented from being introduced in a liquid state, which otherwise would cause a liquid compression, thereby preventing the compressor from being damaged.

Furthermore, according to the present invention, the refrigerant at the inlet (bottom) tank **48** is introduced, via all of the refrigerant evaporating passageways **100**, into the outlet (upper) tank **49** while the direction of the flow of the refrigerant is unchanged, thereby reducing a pressure loss at the evaporating passageways **100** while reducing an average value of the evaporating pressure of the refrigerant at the stacked refrigerant evaporator **5**. Due to the reduction in the evaporating temperature, an increased temperature difference is obtained between the refrigerant flowing in the plurality of the refrigerant passageways **100** and the air contacting with the outer wall of the heat exchanging pipes, thereby enhancing a heat exchanging capacity at the stacked heat exchanger **5**, i.e., the air cooling capacity. According to a test by the inventor, it was found that an increase in 12% in the cooling capacity is obtained by the construction of the present invention over the prior art structure where the direction of the flow is turned triple.

The embodiment as explained above is directed to an application of an idea of the present invention to a stacked type evaporator for a refrigerating system in an air conditioning apparatus for an automobile. However, the present invention can be applied to other fields such as an air conditioning apparatus for a building.

Furthermore, in place of the stacked type of evaporator, other type of evaporator can be used, such as that includes a serpentine circular tube with plate fins or a tube of a different cross sectional shape with corrugated fins.

Furthermore, in the shown embodiment, only one fixed throttle **33** is arranged between the inflow passageway **38** of the refrigerant-refrigerant heat exchanger section **32** and the evaporating passageways **100** of the refrigerant-air heat exchanger section **34**. However, a plurality of such orifices can be provided. Furthermore, in place of the orifice of the fixed type as shown, a variable type of orifice can be employed.

Finally, in the shown embodiment, the refrigerating system is of a receiver cycle type including the receiver **17**. However, an accumulator cycle type of refrigerating system can also be employed. Furthermore, in place of a temperature operated expansion valve, a fixed type expansion valve such as a capillary tube or an orifice can be employed.

We claim:

1. An evaporator comprising:

a first heat exchanger for obtaining a heat exchange between a flow of a refrigerant and a flow of an air, and;

a second heat exchanger having an inflow passageway and an outflow passageway, which are arranged to obtain a heat exchange between a flow of the refrigerant in the inflow passageway and a flow of the refrigerant in the outflow passageway;

said first heat exchanger comprising an inlet tank connected to the inflow passageway for receiving the flow of the refrigerant therefrom, an outlet tank arranged above the inlet tank and connected to the outflow passageway for discharging the flow of the refrigerant therefrom and air-refrigerant heat exchanging means for defining a plurality of heat exchange passageways horizontally spaced in parallel, all of the heat exchanging passageways being, at their bottom ends, connected to the inlet tank and, at their top ends, to the outlet tank, thereby obtaining one way flow of the refrigerant in the heat exchange passageways from said bottom ends to said top ends.

2. An evaporator according to claim **1**, wherein said air-refrigerant heat exchanging means comprises a plurality of horizontally spaced heat exchanging units, each of which is constructed by a pair of heat exchanging plates;

each of plates having a recess on one side and top and bottom cup shaped projections;

the heat exchanging plates in each pair being arranged in such a manner than the recesses are arranged to be faced with each other thereby forming a heat exchanging passageway therebetween;

the heat exchanging units, which are adjacent with each other, being arranged in such a manner that the bottom and top cup shaped portions are in communication with each other so that the bottom, inlet tank and the top, outlet tank are respectively formed.

3. An evaporator comprising:

a first heat exchanger for obtaining a heat exchange between a flow of a refrigerant and a flow of an air; and

a second heat exchanger having an inflow passageway and an outflow passageway, which are arranged to obtain a heat exchange between a flow of the refrigerant in the inflow passageway and a flow of the refrigerant in the outflow passageway;

said first heat exchanger comprising an inlet tank connected to the inflow passageway for receiving the flow of the refrigerant therefrom, an outlet tank arranged above the inlet tank and connected to the outflow passageway for discharging the flow of the refrigerant therefrom and air-refrigerant heat exchanging means for defining a plurality of heat exchange passageways horizontally spaced in parallel, all of the heat exchanging passageways being, at their bottom ends, connected to the inlet tank and, at their top ends, to the outlet tank, thereby obtaining one way flow of the refrigerant in the heat exchange passageways from said bottom ends to said top ends, wherein it further comprises an orifice arranged in the inflow passageway of the second heat exchanger at a location downstream of the inflow passageway adjacent to the inlet tank.

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